with alternating feebler and stronger developments. A maximum in October was especially well marked. It is remarkable that Bishop's ring could not be certainly recognized until January, 1903; it was measured around both the sun and moon, respectively.

Of course, an effort was made to bring these phenomena into connection with the outburst of volcanoes in the West Indies. Now the first violent eruption of Mount Pelée occurred on the 8th of May, 1902. It would, therefore, have required six weeks for the dust to arrive at that stratum of air above Heidelberg where the purple light originates. But other observations, namely the daily observations of insolation, seem to indicate that the dust had hovered over us somewhat earlier. The following are the pentadal averages of the observations of the radiation thermometer. [Presumably the black bulb in vacuo of the Arago-Davy actinometer.—ED.]

Pentads.	Mean of the radiation maxima.
	°C.
May 26–31	45.8
June 1–5	49.9
June 6–10	39.3
June 11–15	39.1
June 16–20	40.0
June 21–25	41.2
June 26–30	46.4

From these figures it would seem probable that the obscuration due to the dust occurred over this observatory about or before the 10th of June, which corresponds to a velocity of five weeks instead of the six weeks above given.

During the whole of the second half of the year the astronomical transparency of the atmosphere was much less than usual.

One must be very careful not to misinterpret the readings of the Arago-Davy actinometer. The correct theory of the action of this instrument was first given by Prof. William Ferrel in his memoir on the temperature of the atmosphere and earth's surface, pp. 34–48, "Professional papers of the Signal Service, No. XIII, Washington, 1884." See also Ferrel's "Recent advances;" also Prof. Winslow Upton's report on the actinometric observations made during the United States Eclipse Expedition to the Caroline Islands. According to Ferrel the insolation must not be measured by the mere reading of the maximum thermometer, but depends upon both this and the difference between the bright and black bulb, and must be computed by the formula

$$I = 4.584\mu^{\theta_1}\left(\mu^{\theta-\theta_1} - 1\right)\frac{1}{1-4\rho_1}$$

in which he assumes that the two conjugate thermometers have spherical bulbs. ρ_1 is the relative absorbing power of the bright bulb as compared with the black bulb, and must be determined for each instrument. θ is the temperature of the black bulb, θ_1 is the temperature of the bright bulb, μ is the constant, 1.0077, as determined by Dulong and Petit. The following table, quoted from Ferrel, illustrates the working of this formula:

Values of I for different values of θ and θ₁.

θ_1.	$\theta-\theta_1$.			
	10° C.	20° C.	30° C.	40° C.
°C.				
−10	0.339	0.705	1.099	1.525
0	0.366	0.761	1.187	1.646
+10	0.395	0.822	1.282	1.778
20	0.426	0.887	1.385	1.920
30	0.460	0.958	1.495	2.073

ED.

ORIGIN OF AMERICAN COLD WAVES.

In a letter of January 26 to Prof. R. F. Stupart, the Editor said:

I have just read an old excerpt from the Cœur d'Alene Sun. We have taken careful note of the development of these cold waves in the Klondike, and it usually takes three weeks for them to travel down to the weather stations at Edmonton, Qu'Appelle, and Havre.

I myself suppose that the cold of cold waves is due entirely to the radiation of heat from the lower strata of the atmosphere to ground and to the clear sky overhead, as explained in my article on "Atmospheric radiation and its importance in meteorology," published in the American Journal of Science in 1892, and reprinted in the American Meteorological Journal, vol. 8, p. 537. I suppose, therefore, that a cold wave may originate anywhere along the western slope of the Rocky Mountains, and its coldness when it reaches Montana would depend on the slowness with which it has moved southward, so that it may possibly be true that the very coldest temperatures come with cold waves that have taken three weeks to move from the Klondike southward. I am rather inclined to doubt whether any of our cold waves, at least those worthy the name, originate north of British America, but that they all begin with the clear air that flows over the northern part of the Rocky Mountain range.

Under date of February 9, 1904, Professor Stupart replied as follows:

I am studying the question, using the data from Dawson, Fort Good Hope, Chippewyan, Fort Churchill, York Factory, Edmonton, and Winnipeg. In a short time I shall hope to send you something further. I am almost satisfied that the Cœur d'Alene Sun is astray in supposing that it takes three weeks for cold waves to travel from the Klondike to Alberta and Havre. There is, I think, some ground for a belief that in many seasons the cold waves take about six days. This is indicated in the winters of 1901–2 and 1902–3, but it is certainly true that in some seasons waves of intense cold which are experienced in the far north never reach Alberta or even Winnipeg. This present winter, in December the coldest weather seems to have occurred simultaneously at Dawson, Edmonton, and Winnipeg. In January the greatest cold wave set in at Dawson on the 9th or 10th, and the coldest weather of the month began at Edmonton on the 15th. This is also about six days. But this present month another great cold wave set in over the Yukon on the 2d, and almost coincidently the weather turned decidedly cold at Edmonton.

I spent the winter of 1884–1885 in Hudson Strait on the barren grounds. February of that winter was there exceedingly mild for that region, while in Toronto it was the coldest month, but one, recorded in seventy years. I quite agree with you that probably none of the cold waves originate north of British America, but it appears to me that they may originate almost anywhere over the more northern portions of the continent. The cold waves which have passed across the Great Lakes and the St. Lawrence Valley this winter do not appear to have originated in the far northwest, or at least they have become much more intense as they approached Ontario and Quebec.

With regard to the cold of cold waves being entirely due to the radiation of heat from the lower strata of atmosphere to the clear sky overhead, I can not offer other explanation, but at the same time, I doubt whether it is the full explanation. In some winters great cold waves persistently form, while in other years, with barometric and cloud conditions as far as we can judge almost identical, the resulting cold waves are relatively unimportant.

I do not believe in moon or planets having any appreciable effect on the terrestrial weather. The sun alone is to be considered, and I hope there is now some ground for belief that the physicist may shortly give us information regarding solar radiations which may assist in solving some of the perplexing problems in meteorology.

DESTRUCTIVE STORMS IN KENTUCKY, FEBRUARY 7, 1904.

By H. B. HERSEY, Inspector, Weather Bureau.

Very severe destructive local storms occurred at many places in Kentucky during the early morning hours of February 7, 1904.

In several localities these storms assumed the characteristics of a tornado. Occurring between 2 and 5 o'clock in the morning, when few people were awake, accurate description of the sky and clouds are not obtainable, but an examination of the effects of these storms shows that some of them were tornadoes.

While the season and time of day were not favorable to such storms, the pressure and temperature conditions were favorable. At 7 p. m. of February 6 there was an area of very low pressure central over Illinois, with secondary disturbances in Oklahoma and Colorado. These centers must have developed

greater energy during the night of the 6th and concentrated just north of the Ohio River.

At Louisville the barograph registered the least pressure, 28.90 inches (actual), about 3:40 a. m. of the 7th. This was followed by a sudden increase, amounting to .15 inch within thirty minutes. The temperature at Louisville at 3 a. m. of the 7th was 67°, very high for the hour and season.

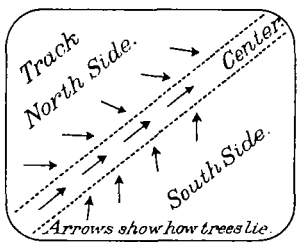
Thunderstorms, high winds, and heavy rains were general throughout the Ohio Valley during the same night.

At Cecilian, in Hardin County, two churches and several smaller buildings were destroyed and many houses unroofed or severely damaged. One of the churches, a very substantial brick building, was leveled to the ground, with the exception of a portion of the front wall, which was left standing. The rectory, standing within a few feet of the church, was uninjured. The other church was a lighter building. This was entirely demolished, even the foundation stones being moved out of place.

This occurred about 4:30 in the morning of the 7th. The destructive part of the storm lasted less than five minutes. The sky was inky black, except when lighted by vivid flashes of lightning.

Rev. J. J. Abell, of Bethlehem Academy, St. John, Hardin County, reports:

The violent storm of February 7 passed through the southeast side of Cecilian, which is 4 miles southeast of here. The exact time at Cecilian was at 4:25 a. m., central time. The rain was very heavy for about fifteen minutes. The direction of the storm's movement through Cecilia was north 51° east; the path of greatest destruction was about 3 miles long and 240 yards wide. Lightning was almost continuous. The direction in which trees fell is shown by the accompanying diagram.



In Ohio County, about 3:45 the same morning, a similar storm struck the little village of Narrows, practically wiping it out. The town consisted of about thirty residences and six business houses, and of these not one escaped severe injury and many were entirely destroyed. The path of this tornado seems to have extended from Dundee to Narrows, a distance of about 3 miles.

In many other localities in the central and northern portions of the State destructive storms occurred about the same time. Great damage was done to buildings and much property destroyed, but strange to say no lives were lost.

TORNADO AT MERIDIAN, ILL.

The following is summarized from a report, accompanied by a clipping from the Cairo Citizen, by Mr. Lewis Redding, of a tornado that struck the residence of the latter at Meridian, Ill., on February 7. The family were awakened by a clap of thunder, "the loudest I ever heard" at about 2 a. m., and the tornado struck the house a minute later with a roar like a train of cars. The building, which was two stories and a half high and very substantially built, was lifted from its brick foundations, turned around, and dropped. All the other buildings on the place, with the exception of the barn, were wrecked, and portions of them were carried more than a mile away. An oak tree 20 inches in diameter was twisted into splinters. The storm moved from southwest to northeast, over a path ten rods in width. The shape and motion of the clouds could not be observed, but the manner in which the débris was scattered indicates that the wind had the whirling motion characteristic of tornadoes. There was no loss of life, and the property loss, exclusive of damage to the house, was about $3000.

Meridian is about two miles east of Villa Ridge and 9 miles north of Cairo. The Weather Bureau office at Cairo reports a storm accompanied by extremely vivid lightning and moderate thunder. The wind reached a maximum velocity of 66 miles per hour at 2:41 a. m., and considerable damage was done.

RAIN AT FREEZING TEMPERATURES.

By E. D. EMIGH, Assistant Observer, Dodge City, Kans.

As my reports of rain and freezing temperatures at 8 p. m., January 1, and 8 a. m., February 17, have been questioned because of their apparent inconsistency, I would report in detail the following extract from the station record:

January 1, 1904.—Light misty rain, amounting to .02 of an inch, fell from 9:15 a. m., to 8:45 p. m., seventy-fifth meridian time, the maximum temperature during the entire duration of the storm being 23°, while a minimum of 20° was recorded. Though light snow accompanied the rain at intervals during the afternoon, the mist reached the ground in liquid form, and froze in solid sheets of ice on the sidewalks, sides of buildings, the ground, and whatever else it struck, indicating conclusively the existence of a stratum of warm air at no great elevation.

February 17, 1904.—In all essential particulars, this storm was identical with that of January 1. The existing temperature and its range, the character and amount of precipitation, and the prevalence of northerly wind and rising pressure were almost exactly the same. In this storm, however, no snow accompanied the rain, and it may also be of interest to note that several hours of its duration were at night.

The determination of the direction of cloud movement in these disturbances is a matter of considerable difficulty, but clearing weather about six hours after the ending of precipitation on the 17th of February disclosed a moderate velocity from the southwest at the stratus cloud level. It seems that the air currents even at comparatively low elevations have directions differing very materially from those at the earth's surface.

FORMATION OF CLOUDS OVER LAKE MICHIGAN IN WINTER.

By Rev. CHARLES H. LEE, Racine, Wis., February 14, 1904.

The influence of lakes on local climate has been frequently referred to in the MONTHLY WEATHER REVIEW.[1] The following remarks contained in a letter to Prof. Frank H. Bigelow from Rev. Charles H. Lee, of Racine, Wis., under date of February 14, 1904, throw additional light upon the subject, since this careful observer has watched the formation of clouds over the lake as observers can not do at stations farther east, because so much of the time they are enveloped in the clouds:

Has the station at Milwaukee this winter noted the frequency of cloud movements from the northeast during periods of high? Apparently these movements occur with the onset of a southwestern low, and they are almost always followed by a northeaster, and consequent rise in surface temperature. Sometimes these clouds come up against a clear sky; sometimes against a sky marked by a thin line of cirrus, which seem to move more from the west than from the northwest, surface currents being always at these times from the northwest. I have several times predicted warmer weather and northeast winds, and I don't think I have missed it once. The clouds from the northeast are clearly aqueous vapor from over the lake, and can be seen gathering on the eastern horizon and slowly moving landward. It usually happens about noon, after a clear, cold morning, with the temperature about 0° F. When the temperature is below 0°, the whole surface of the lake steams like a boiling kettle, but when the sun is well up and the temperature has risen to + 5° or + 10° the *steaming* ceases and the eastern sky is massed full of this accumulated vapor, which seems to *break off* and slowly float shoreward, sometimes almost like a small summer cumulus. It makes an excellent illustration of your remark that "masses of air at different temperatures are reluctant to lose their individuality." It is usually about twelve to eighteen hours before the northeast surface current is established. Once or twice it lasted only a short time, the wind backing again to the northwest.

Just now things are peculiar, the lake being frozen wholly over for several miles, to the utter confusion of gulls and fish ducks, which are reduced to semistarvation and come ashore in flocks to attack garbage piles and sewer openings, and pathetically hunt possible air-holes. Yes-

[1] See Monthly Weather Review, 1891, Vol. XXIX, pp. 422 and 563; 1892, Vol. XXX, p. 135.